

PERFORMANCE OF GERMINATION, GROWTH AND NODULATION OF LEGUMINOUS TREE SPECIES UNDER NURSERY CONDITION

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Abstract

Eight tree legumes species, namely- *Albizia procera* (Indian provenance), *Albizia chinensis* (Indian provenance), *Albizia procera* (local), *Albizia richardiana*, *Albizia chinensis*, *Leucaena leucocephala*, *Acacia auriculiformis* and *Acacia mangium* were tested at Bangladesh Forest Research Institute during 2006 to select suitable species for the reforestation programs in the degraded hilly areas. Germination percentage (99 %) was found higher in *Albizia procera* while *L. leucocephala* species showed higher germination value (22.45%) but *Leucaena leucocephala* showed higher sturdiness (16.90) and *Albizia richardiana* root-shoot ratio (2.72) in comparison to the remaining species. The shoot length, collar diameter and root length were higher in *L. leucocephala*, *A. procera* (Indian provenance) and *A. auriculiformis*. The former species showed higher nodule number but the total biomass, quality index and vigor index were significantly higher in *A. procera* (Indian provenance) and *L. leucocephala*. Considering the percentage of scoring of all these parameters, *L. leucocephala* ranked highest followed by *A. auriculiformis*, and has been considered suitable species for plantation programs in degraded soils in hilly areas.

Introduction

The degraded hill forest areas of Bangladesh suffer from low fertility and creating problems for the successful establishment of plantations of some common timber species (Hossain *et al.* 2001). Nitrogen fixing tree species (NFTs) may be considered suitable for successful plantation programs in such degraded forest areas as they may enrich the depleted soil by atmospheric nitrogen fixation through their root nodules (Chaukiyal *et al.* 1999 and 2000). Leguminous trees also help in speedy recovery of degraded lands due to fast decomposition of litter fall (Anegbeh *et al.* 1999, Prinsen 1986 and Semwal *et al.* 2003). Considering the importance of nitrogen fixing tree species to increase soil fertility and improving the forest productivity of plantation programs, legumes are priority tree species in plantations programs. Legumes are also multipurpose, colonizing, fast growing forest tree species and are common tree components in agroforestry and other participatory forestry practices in the country. But, information on seed germination, seedling growth and nodulation potential of tree legumes species are scant in Bangladesh. In this context, an experiment was established with some leguminous tree species, viz., *A. procera*, (Indian provenance), *A. chinensis*– (Indian provenance), *A. procera* (local), *A. richardiana*, *A. chinensis*, *L. leucocephala*, *A. auriculiformis*, and *A. mangium* in the nursery of Bangladesh Forest Research Institute (BFRI) with the objective of the study was to assess the germination, growth and root nodulation behavior of the species in the nursery.

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Materials and Methods

The study was conducted in the nursery of Silviculture Research Division (SRD) of BFRI, Chittagong in 2006. Seeds were collected from Seed Orchard Division (SOD) of BFRI. In addition to the local seed sources, seeds of *A. procera* and *A. chinensis* were collected from Uttar Pradesh, India and treated as Indian provenances. Seeds were sown in 23 cm x 15 cm size polybag filled in with forest top soil and decomposed cow-dung in a proportion of 3:1. Seeds of all the species were treated with hot water for 30 seconds before sowing. A total of 800 polyethylene bags were filled and seeds were sown for all six species (8 species/provenances) x 4 replications x 800 polyethylene bags). Three seeds of each species were sown in a polybag at equal depth and 15 cm apart from each other. Watering was carried out regularly by fine shower which could not disturb the seedlings physically. Weedings and cleaning were done as and when necessary. Seed germination records maintained daily till 70 days of the experiment. After 50 days of seed sown, one healthy seedling was kept in each polybag and others were removed carefully. Seedlings height, root height, shoot height, collar diameter and dry root biomass of shoot and nodules were recorded. After 150 days of seed sown, five seedlings were randomly collected from the nursery. Then the seedlings were carefully washed with tap water and roots of the seedlings were floated in water. The washed roots were wrapped with soft tissue paper and nodules were detached from individual seedlings and further washed carefully to remove all particles. Fresh weights as well as dry weight of different components of the seedlings were recorded. The germination values (GV) were calculated by using the formula of Djavanshir and Pourbeik (1976):

$$GV = (\sum DGs / N) \times GP / 10$$

Where,	GV	=	Germination value
	GP	=	Germination percentage at the end of the test
	DGs	=	Daily germination speed obtained by dividing the cumulative germination percentage by the number of days since sowing
	Σ DGs	=	The total germination obtained by adding every DGs value obtained from the daily count
	N	=	The total number of daily counts, starting from the date of first germination
	10	=	Constant

To assess the seedling vigor index, total height (from the soil surface to seedling tip) of each seedling was measured using a ruler to nearest 0.1 cm. Vigor index was calculated according to Baki and Anderson (1973) as germination percent x seedling total length, i.e., total shoot and root length.

Quality Index (QI) to qualify seedling morphological quality was calculated following the method of Dickson and Hosner (1960):

Quality Index (QI) = Total weight (g) ÷ [{Height (cm) ÷ Collar diameter. (cm)} + {Shoot dry weight (g) ÷ (Root dry weight (g))}]

The Sturdiness and Root-shoot ratio were calculated:

Sturdiness = Height ÷ Collar diameter

Root-shoot ratio = Total green weight of root ÷ Total green weight of shoot

Duncan Multiple Range Test (DMRT) was applied to compare the differences of all the species.

Results and Discussion

Germination percentage was maximum (99%) in *A. procera* (local) followed by *A. chinensis* (88%), *L. leucocephala* (79%), *A. auriculiformis* (76%) and *A. mangium* (73%). However, poor germination was found in *A. procera* (Indian Provenance) (32%), *A. richardiana* (32%) and *A. chinensis* (Indian provenance) as 39%. Highest sturdiness attained in *A. auriculiformis* (16.90) followed by *L. leucocephala* (14.82) and *A. procera* (13.02) and lowest sturdiness attained in *A. procera* (Indian provenance) as 9.82. The root-shoot ratio of all the species was less than 1 except in *A. richardiana* (2.72) and *L. leucocephala* (1.76). However, germination value was highest (22.45) in *L. leucocephala* followed by *A. mangium* (18.65) and *A. chinensis* (18.08) whereas lower germination value attained in *A. richardiana* (1.40) but at par to *A. procera* Indian provenance (2.10) and *A. chinensis* - Indian provenance (4.35) (Table 1).

Table 1. Germination (%), sturdiness, root-shoot ratio and germination value (GV) of six tree legume seedlings in nursery

Species	Germination (%)	Sturdiness	Root-Shoot ratio	Germination value
<i>Albizia procera</i> - Indian provenance	32 b*	9.82 c	0.84 b	2.10 d
<i>Albizia chinensis</i> - Indian provenance	39 b	11.85 bc	0.99 b	4.35 d
<i>Albizia procera</i>	99 a	13.02 abc	0.72 b	16.67 b
<i>Albizia richardiana</i>	32 b	10.47 bc	2.72 a	1.40 d
<i>Albizia chinensis</i>	88 a	12.22 bc	0.65 b	18.08 ab
<i>Leucaena leucocephala</i>	79 a	14.82 ab	1.76 a	22.45 a
<i>Acacia auriculiformis</i>	76 a	16.90 a	0.88 b	11.18 c
<i>Acacia mangium</i>	73 a	10.17 bc	0.80 b	18.65 ab

*The same letter(s) in the same column are not significantly different by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Seedling growth performances, e.g., seedlings height, root length, collar diameter, green weight of the seedlings (leaf, shoot and root), nodules number and dry weight were assessed with some legume forest tree species in the nursery. The mean height of the seedlings was highest (111.5 cm) in *L. leucocephala* which significantly different from the rest species (Table 2). Lower height was found in *A. mangium* (29.8cm) followed by *A. richardiana* (35.27 cm) and *A. auriculiformis* (46.49 cm).

Considering collar diameter of the seedlings, *A. procera*- Indian provenance attained highest collar diameter (8.28 mm) which significantly different from others. The mean lower collar diameter attained in *A. auriculiformis* (2.97 mm) which was at par to *A. mangium* (3.20 mm), *A. richardiana* (3.25 mm) and *A. chinensis*- Indian provenance (4.89 mm). The species *A. auriculiformis* possessed higher root length (38.8 cm) followed by *A. procera* (Indian provenance) (35.95 cm) and *L. leucocephala* (34.87 cm). Mean total green weight was maximum (86.05 g) in *A. procera*- Indian provenance closely followed by *L. leucocephala* (85.50 g) whereas lower in *A. mangium* (11.70 g). The number of nodules was maximum in *L. leucocephala* (43) followed by *A. chinensis* (36) and lowest nodules number attained in *A. richardiana* (2). However, the nodule dry weight was maximum (0.25 g) in *A. chinensis* - Indian provenance followed by *A. procera* (0.20 g), *A. procera*- Indian provenance (0.20g) and *A. auriculiformis* (0.15 g) (Table 2). The air dry weight of seedlings (leaf, shoot and root) of different species was statistically significant (Table 3). Mean leaf and twig was higher (10.39 g) in *A. chinensis* - Indian provenance followed by *A. procera* Indian provenance (9.34 g), *L. leucocephala* (8.0 g), *A. chinensis* (7.05 g) and *A. auriculiformis* (3.55 g). Considering the mean shoot dry weight of the

Table 2. Comparative shoot length, collar diameter, root length, total green weight, nodule number and weight of the seedlings

Species	Shoot length (cm)	Collar diameter (mm)	Root length (cm)	Green weight (g)			Total green weight (g)	Nodules number	Nodule dry weight (g)
				Leaf and twig	Shoot	Root			
<i>Albizia procera</i> -Indian provenance	82.19 b	8.28 a	35.95 ab	40.50 a	25.65 ab	19.90 ab	86.05 a	18 bc	0.20 ab
<i>Albizia chinensis</i> - Indian provenance	58.66 bc	4.89 cd	26.05 bc	28.55 abc	17.40 bcd	16.70 b	62.65 ab	18 bc	0.25 a
<i>Albizia procera</i>	74.7 b	6.04 bc	27.6 bc	14.4 abc	11.93 cde	8.80 b	35.13 bc	16 bc	0.20 ab
<i>Albizia richardiana</i>	35.27 cd	3.25 d	18.3 c	2.9 c	2.55 e	6.65 b	12.10 c	2 d	0.01 d
<i>Albizia chinensis</i>	71.68 b	5.91 bc	23.55 c	32.50 ab	20.25 abc	13.10 b	65.85 ab	36 a	0.12 bcd
<i>Leucaena leucocephala</i>	111.53 a	7.53 bc	34.87 ab	19.90 abc	31.40 a	34.20 a	85.50 a	43 a	0.09 cd
<i>Acacia auriculiformis</i>	46.49 cd	2.97 d	38.8 a	14.30 abc	8.30 de	6.90 b	29.50 bc	21 b	0.15 abc
<i>Acacia mangium</i>	29.80 d	3.20 d	28.15 bc	4.95 bc	3.75 e	3.00 b	11.70 c	7 cd	0.05 cd

- Letter(s) in the same column are not significantly different by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

L. leucocephala produced the maximum shoot dry weight (11.73 g) followed by *A. chinensis* -Indian provenance (10.35 g) and *A. procera* Indian provenance (8.03 g) and lowest by *A. mangium* (0.75 g). Similarly, root dry weight was maximum (8.13 g) in *A. chinensis* - Indian provenance followed by *A. procera* Indian provenance (6.29 g), *L. leucocephala* (5.8 g), *A. procera* (4.69 g), and *A. chinensis* (4.53 g) and lowest by *A. mangium* (0.27 g). The total dry weight was maximum (28.86 g) in *A. chinensis* - Indian provenance followed by *L. leucocephala* (25.53 g), *A. procera* (Indian) (23.66 g) and *A. chinensis* (20.18 g) and lower dry weight attained by *A. mangium* (1.88 g) followed by *A. richardiana* (6.0 g), *A. auriculiformis* (8.84 g) and *A. procera* (10.39 g).

Vigor index varied significantly among the seedlings though there was variation among the species. *L. leucocephala* possessed higher vigor index (11516.1) followed by *A. procera* (10130.1) while lower value (1378.9) in *A. richardiana*. Both indian species, *A. chinensis* and *L. leucocephala* showed similar quality index which was significantly at par. The lower quality index was obtained from *A. mangium* followed by *A. auriculiformis* (Table 3).

It is difficult to ranking the growth of plants in sequential order considering all the parameter together. Therefore, a numerical ranking system was followed taking into consideration the total number of studied plants and parameters. All the species were graded one to six considering their responses from higher to lower order for the individual parameter and finally scores obtained by each plant for all parameters were added and percentage value were calculated (Thatoi et al. 1995).

Table 3. Total dry weight, vigor index and quality index of the seedlings grown in polybags

Species	Air Dry weight (g)			Total dry weight (g)	Vigor index	Quality index
	Leaf and twig	Shoot	Root			
<i>Albizia procera</i> - Indian provenance	9.34 ab	8.03 abc	6.29 ab	23.66 a	3954.8 de	2.17 a
<i>Albizia chinensis</i> - Indian provenance	10.39 a	10.35 a	8.13 a	28.86 a	3095.8 ef	2.19 a
<i>Albizia procera</i>	1.96 bc	3.74 bcd	4.69 abc	10.39 bc	10130.1 ab	0.67 bcd
<i>Albizia richardiana</i>	2.00 bc	2.00 d	2.00 cd	6.00 c	1378.9 f	0.56 bcd
<i>Albizia chinensis</i>	7.05 abc	8.60 ab	4.53 abc	20.18 ab	8393.0 bc	1.42 abc
<i>Leucaena leucocephala</i>	8.00 abc	11.73 a	5.80 abc	25.53 a	11516.1 a	1.5 ab
<i>Acacia auriculiformis</i>	3.55 abc	2.96 cd	2.33 bcd	8.84 bc	6294.4 cd	0.48 cd
<i>Acacia mangium</i>	0.86 c	0.75 d	0.27 d	1.88 c	4190.3 de	0.15 d

Letter(s) in the same column are not significantly different by DMRT at 5% level of probability

Conclusion

Considering the percentage scoring, it was found that *L. leucocephala* occupied the highest rank followed by *A. procera*, *A. chinensis*, *A. auriculiformis*, *A. mangium*, *A. procera* -Indian provenance, *A. chinensis* - Indian provenance and *A. richardiana*. The poorest of performance was found in *A. richardiana*. Considering scoring data, *L. leucocephala* is considered as a suitable species for the plantation programs followed by others. Since the highest root length attained in *A. auriculiformis* and *L. leucocephala*, these species are suitable for plantation programmes followed by others in degraded soils in hilly areas of Chittagong and Chittagong Hill Tracts. However, further research should be carried out with more leguminous multipurpose forest tree species at field level before taking for large scale plantation programs in degraded hilly areas.

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